

OBSERVATIONS ON THE EFFECTS OF FIRE IN MOUNTAIN FYNBOS AT ZACHARIASHOEK, PAARL

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ABSTRACT

Changes in composition and structure of fynbos plant communities after an experimental fire in the Zachariashoek research area near Paarl, Cape Province, were assessed by means of a sample of 31 fixed 50 m² quadrats before the burn in November 1971 and again six years later.

Results show little change in vegetation between 1971 and 1977. The mean number of species per plot did not differ significantly nor did evenness or dominance concentration. Composition as measured in each plot by the relative cover-abundance of species changed by about 33% on average but when measured by species presence and absence the change amounted to some 50%. Such apparent compositional changes were however ascribed principally to misidentification of rare species and other observer errors, and local small shifts in distributional patterns, because the frequency and mean relative cover of prominent species changed little. No major changes in vegetation structure, i.e. canopy height, cover, and growth form composition, were apparent, though canopy cover seemed to decline somewhat and seed-regenerating shrubs were slightly reduced in importance.

Communities had already been subject to artificial disturbance before the burn and are therefore not likely to have represented the naturally prevalent vegetation of the area.

Thus although the vegetation largely recovered its pre-burn condition within six years this would not necessarily be the case in pristine or nearly pristine fynbos.

UITTREKSEL

WAARNEMINGS OP DIE INVLOED VAN VUUR IN BERG FYNBOS TE ZACHARIASHOEK, PAARL

Verandering in samestelling en struktuur van fynbos plantgemeenskappe in die Zachariashoek navorsingsgebied naby Paarl, Kaaprovinsie, na 'n eksperimentele brand, is vasgestel deur middel van bemonstering van 31 permanente 50 m² persele, voor die brand in November 1971 en weer ses jaar daarna.

Resultate het min verandering in die plantegroei tussen 1971 en 1977 aangetoon. Die gemiddelde aantal soorte asook die mate van gelykmatigheid, en konsentrasie van dominansie per perseel het nie beduidend verskil nie. Samestelling van elke perseel soos deur middel van relatiewe dekkinggraad gemeet, het met omtrent 33% verander, maar het met omtrent 50% verander as dit deur middel van aan- of afwesigheid van soorte gemeet word. Sulke oënskynlike verandering in samestelling kan grootliks toegeskrywe word aan verkeerde uitkenning van skaars soorte, waarnemingsfoute, en klein plaaslike veranderinge in verspreidingspatrone, aangesien die frekwensie en gemiddelde relatiewe dekking van opvallende individuele soorte min verander het. Geen noemenswaardige veranderinge in gemeenskapstruktuur, d.w.s. hoogte, dekking en groeivormsamestelling, is waargeneem nie, alhoewel kroondekking skynbaar afgeneem het en belangrikheidsgraad van generatiewe struik ietwat verlaag was.

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Gemeenskappe is voorheen kunsmatig versteur voordat dit gebrand is en het waarskynlik nie die natuurlike heersende plantegroei van die gebied verteenwoordig nie.

Dus, alhoewel die plantegroei grotendeels herstel het tot die toestand wat voor die brand geheers het, sal dit nie noodwendig die geval wees by ongeskonde of byna ongeskonde fynbos nie.

INTRODUCTION

The Zachariashoek experiment, discussed in detail by Van der Zel (1974), was established in 1965 to investigate the influence of controlled burning of Mountain Fynbos (Veld Type 69: Acocks, 1953) on water yield, erosion, and vegetation composition. The experiment includes three main experimental sub-catchments, Kasteelkloof (324,5 ha), Zachariashoek (287 ha) and Bakkerskloof (356,4 ha). Treatments consist of late spring (November) burns on six and on 12 year rotations in the Kasteelkloof and Zachariashoek sub-catchments respectively, and protection from fire in Bakkerskloof. This paper reports on change in the fynbos communities in the Kasteelkloof sub-catchment following the first prescribed treatment period.

The research area is located near Paarl in the south-western Cape Province, and is centred at 34° 49' and 19° 02' in quarter-degree square 3319CC (Fig. 1). Elevation ranges from 240 to 850 m overall but from 240 to 765 m in the Kasteelkloof sub-catchment. The only geological formation present is the Table Mountain Group, which comprises sandstones of the Peninsula and Nardouw Formations, tillites of the Pakhuis Formation, and shales and mudstones of the Cedarberg Formation (the shale band). Sandstones are the dominant parent material.

Climate is typical of mountains of the winter-rainfall zone (e.g. Schulze, 1965; Kruger, 1979). Annual rainfall in Kasteelkloof varies between 930 and 2 300 mm with a mean over eight years of 1 458 mm: further data are reported by Van der Zel (loc. cit).

VEGETATION

The dominant vegetation is a low restioid herbland, or an open low narrow-sclerophyllous shrubland, both formations dominated by coarse Restionaceae and Cyperaceae. Important genera include *Chondropetalum*, *Hypodiscus*, *Restio*, *Siaberoha*, *Tetralia* and *Pentstemon*. A sparse low sclerophyllous woodland characterised by *Protea nitida* occurs on the talus slopes along the shale band. Trees are otherwise rare. On rocky koppies stunted broad-sclerophyllous trees, mainly *Heeria argentea*, form a closed scrub while in ravines stunted forest of mainly sclerophyllous trees may be found. A detailed report on the vegetation of Zachariashoek is in preparation.

HISTORY OF THE CATCHMENTS

The upper portion of the catchment has always been unoccupied state land.

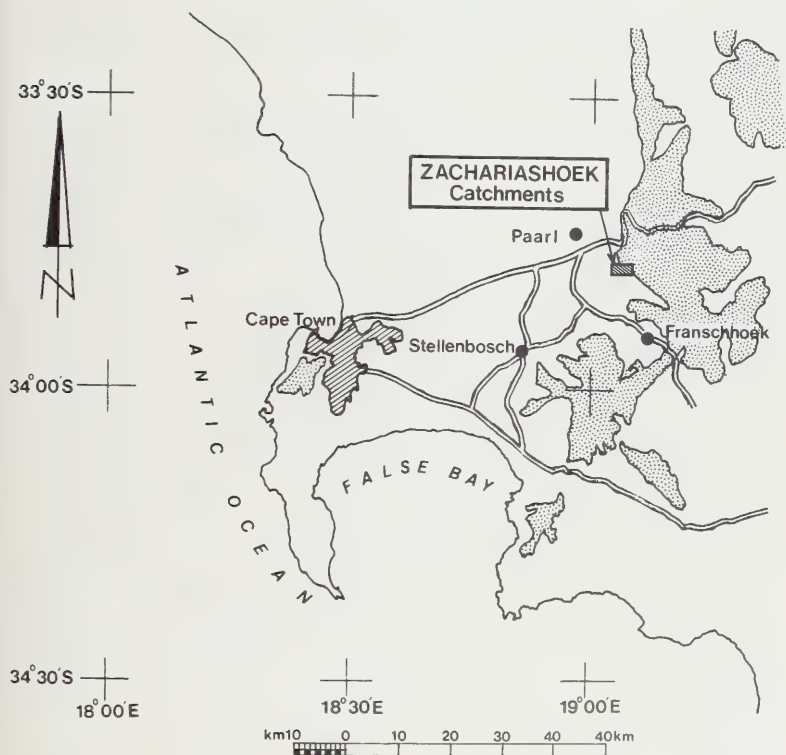


FIG. 1.

Location of the Zachariashoek catchments. Shaded areas represent land at elevations above about 600 m.

The lower portion was granted as freehold in 1839, but transferred to the Department of Forestry in 1940.

There is no record of grazing in the area, but land in private ownership would very likely have been used at a low intensity for seasonal rough pasturage of large and small stock, and this would have been associated with irregular but frequent burning (see, for example, Wicht and Kruger, 1973). Areas of state-owned land would also most likely have been similarly used on a casual basis. Irregular tracks, bare areas and gullies encountered in the catchments are apparent testimony of use by domestic stock. It is unlikely that pasturage was of any real consequence during the past quarter century, and it has certainly been minimal since 1965.

The recent history of fire in the area is fairly well documented, but no records of fires predating 1953 could be found. The entire area appears to have burnt out in two fires in 1953 and 1954, as reflected in the following reports: "The Du Toits Kloof fire raged on the Wemmershoek Mountains from 6–10th March 1953 destroying part of the veld on the Zachariashoek Reserve, the whole of the Wemmershoek Reservoir Area and part of the Wemmershoek Catchment area" (Annual Report of the Conservator of Forests, 1952–53: Department of Forestry files); "A fire started on the City Council land at Wemmershoek or Zachariashoek Forest Reserve (in March 1954), destroying all the veld saved from the fire that ravaged the Klein Drakenstein Mountains during March 1953" (Annual Report of the Conservator of Forests, 1953–54: Department of Forestry files).

TABLE 1.
Fire history of the Zachariashoek catchments

Date of fire	Percentage of sub-catchment area burnt			Cause of fire or reason for burning
	Kasteelkloof	Bakkerskloof	Zachariashoek	
1953–54	100,0	100,0	100,0	Unknown
1960	2,1	31,9	27,1	Unknown
1963	23,8	0,4	0,0	Site preparation for planting
1965	67,4	51,8	12,3	Hakea control
April 1966	0,0	0,0	31,5	Unknown, possibly Hakea control
Aug. 1966	0,0	0,0	14,9	Firebreak
Aug. 1969	3,6	11,6	0,0	Hakea control
Aug. 1970	0,0	0,0	±1,0	S.A. Air Force flare
Aug. 1971	0,0	3,0	10,0	Firebreak
Nov. 1971	100,0	0,0	0,0	Prescribed burn
Sept. 1972	0,0	10,6	0,0	Firebreak
Aug. 1973	0,0	0,0	6,7	Firebreak
Nov. 1977	100,0	0,0	100,0	Prescribed burns

The subsequent fire history for the entire catchment experiment, as obtained from Departmental reports, aerial photographs, and ground observation, is presented in Table 1.

Much of the area, and especially Kasteelkloof, was densely infested by *Hakea sericea* Schrad. and scattered large *Pinus pinaster* Ait. trees before 1965 (J. A. Fenn, 1978, pers. comm.). These woody weeds were cut down by hand and the seed was allowed to germinate before the burn prescribed for 1965. These measures were repeated before the 1971 burn in Kasteelkloof and ensured nearly complete eradication of the weed populations.

Before the decision in 1965 to use the area for research it had been earmarked for timber plantations. The lower portions of Zachariashoek and Kasteelkloof were afforested with *Pinus radiata* D. Don during 1963–64. Site preparation included burning and pitting. The pines were later killed by fire or removed by hand during operations in 1965 and 1971.

Although human influences and fire have pervaded the experimental area their impact has been limited, often being difficult to discern or otherwise local. Implications regarding experimental results are discussed below.

METHODS

A set of 33 permanent quadrats, each 50 m² (5 × 10 m) in area, was established to monitor community composition. Each plot was located on the intersection of a 300 m grid (orientated N-S and E-W) in the Kasteelkloof catchment, and each was marked by means of a creosoted wooden pole planted at a standard bearing and distance from the plot corner.

Each plot was defined by means of braided nylon cords, staked carefully to ensure a rectangular shape. Plots were quartered with shorter cords, to aid cover-abundance estimates.

The vegetation in each plot was analysed in September to October of 1971. All vascular plants in the plot were listed and classified by cover-abundance estimates on the Braun-Blanquet scale, as described by Kuchler (1967). Unidentifiable herbs were listed as such. Species seen in a belt approximately 2 m wide surrounding the plot were also noted, but the surrounds were not searched thoroughly. All but one of the plots were relocated in the spring (September to October) of 1977, and the same procedure followed. One plot did not burn in 1971, and this unit was discarded from our sample. Geophytes and other species which could not be recognized throughout the year were deleted from the data before any analysis.

Field surveys had been preceded by botanical collections so that a reasonable reference herbarium was available; the flora was in any case relatively well known to one of us (F.J.K.). Specimens were collected from species which could not be identified in the field and these were assigned a serial number until positive identification was possible.

One of us (F.J.K.) completed all enumerations during 1971, and participated in much of the field work during 1977. Cover-abundance estimates and field identifications were co-ordinated during joint field excursions. Identification of problematic plant specimens was undertaken jointly in the herbarium.

Total vegetation cover on each plot was estimated in 1971 but not in 1977 because it was thought that these estimates would be too inaccurate to demonstrate small changes in cover. This was unfortunate, because the estimates would have served to indicate large changes (see below). Also, height and cover of vegetation strata were recorded in 1971 but not in 1977. A more exact technique

was adopted in which we recorded heights of an arbitrary sample (not random) of 10 individuals of each prominent species in each plot. Most sites were photographed before and after each burn and these photographs aided later interpretation of results.

Species' mode of post-fire regeneration was determined by observation in the field (species which resprout are easily identified: Martin 1966) or knowledge of their behaviour elsewhere (Van der Merwe, 1966).

RESULTS

Growth forms

All species present in the survey were classified into growth forms, as follows: Trees, shrubs (>1 m in height), low shrubs (between 0.25 and 1 m), dwarf shrubs (less than 0.25 m), Restionaceae, Cyperaceae, Poaceae, and other herbs including ferns. Members of each of these were classified according to mode of regeneration after fire as vegetative (v), germinative (g—regenerating from seed only), or unknown (u).

TABLE 2.
Summary of changes in growth-form composition (see text).

Growth forms	Mode of re-generation	Mean canopy cover, %		Frequency %	
		1971	1977	1971	1977
Trees	v	0.07	0.05	3	3
	g	0.02	0.00	2	0
	u	0.00	0.00	0	0
Shrubs (> 1 m)	v	6.9	10.1	17	18
	g	8.7	4.1	29	29
	u	0.12	1.3	8	7
Low shrubs (0.25 – 1 m)	v	6.0	4.4	29	29
	g	17.7	15.7	30	30
	u	2.4	2.1	21	19
Dwarf shrubs (< 0.25 m)	v	1.0	1.1	26	23
	g	0.66	0.66	20	23
	u	0.17	0.65	8	5
Restionaceae	v	45.1	34.3	31	31
	g	0.00	0.00	0	0
	u	0.00	0.00	0	0
Cyperaceae	v	15.0	8.2	31	30
	g	0.00	0.00	1	0
	u	0.00	0.00	0	0
Poaceae	v	12.1	11.0	29	30
	g	0.08	0.08	6	5
	u	0.00	0.00	0	0
Others	v	5.8	10.6	30	30
	g	0.36	0.44	16	20
	u	0.89	2.2	15	30

Percentage cover values for each species record were assigned to the cover-abundance scale as follows: r = 0,1; + = 0,5; 1 = 3; 2 = 15; 3 = 37,5; 4 = 62,5 and 5 = 87,5 %. Values were accumulated for all species in each growth form in each plot to calculate means for the sample. Data appear in Table 2.

Total cover

A rough estimate of the cover in each plot was obtained by calculating the sum of cover values for each species using the scale conversion presented above. Results appear in Table 3.

TABLE 3.
Comparison of calculated cover values in each plot for both surveys
(see text for explanation)

Plot number	Cover, %		Plot number	Cover, %	
	1971	1977		1971	1977
21	70	65	38	104	84
22	182	142	39	85	87
23	107	170	40	124	94
24	152	190	41	85	94
25	97	73	42	98	57
26	169	127	43	88	78
28	136	139	44	187	166
29	129	146	51	103	100
30	188	175	57	86	100
31	141	120	58	84	54
32	163	57	59	184	163
33	175	72	60	108	111
34	77	50	73	127	145
35	77	65	74	107	99
36	105	59	75	177	165
37	101	60	Mean	120	107

Diversity

Measures of species diversity are presented in Table 4. Simpson's index—a measure of dominance concentration—was calculated for each plot as $C = \sum^s p_i^2$ where s = the number of species in the sample and p_i = the proportional abundance of the i th species (see Whittaker, 1972). The Shannon-Wiener index, which reflects evenness of relative species' abundances in the community, was calculated as $H = - \sum^s p_i \log_{10} p_i$ (Whittaker, 1972).

Height

Grand mean heights for each species measured were calculated from the 1977 data as well as means for each species in each plot. In this manner mean heights for almost all important species occurring in the catchment were obtained. Comparison with estimates for each stratum made during 1971 showed little evident change in the height and stratification. This is supported by examination of photographs of each site (Figs 2 to 7).



FIG. 2.
Plot No. 25 before the burn in 1971.



FIG. 3.
Plot No. 25 in 1977. Note survival and recovery of *Heeria argentea* (extreme left and right) and *Widdringtonia nodiflora* (centre).



FIG. 4.
Plot No. 30 before the burn in 1971.



FIG. 5.
Plot No. 30 in 1977. *Pinus radiata* has been killed by fire or removed subsequently. Shrub with pale inflorescences is *Serruria rosea*. Riparian scrub along stream in background has not returned to 1971 stature, but had apparently been protected against fire for some time before 1971.



FIG. 6.
Plot No. 43 in 1971.



FIG. 7.
Plot No. 43 in 1977. Note depletion of *Leucadendron microcephalum* along drainage line in background.

TABLE 4.
Species diversity data for both surveys
(see explanation in text)

	1971	1977
Number of species in sample	260	267
Mean per plot	39,7	38,9
Standard deviation	10,3	9,9
Maximum per plot	55	57
Minimum per plot	6	7
Number common to both surveys	220	220
Mean Simpson's Index	0,05	0,05
Standard deviation	0,05	0,04
Mean Shannon-Wiener Index	1,45	1,49
Standard deviation	0,20	0,19

Cluster analysis

Relative change in species composition of the vegetation was assessed by means of cluster analysis. Records of botanical composition for each plot in both the 1971 and 1977 surveys were treated as a single data set. The results of a cluster analysis using the Bray and Curtis measure of similarity (Bray and Curtis, 1957), are depicted in Figure 8. A summary of the similarity analysis is presented in Table 5. For this analysis, cover-abundance values were scaled as follows: r = 1, + = 5, 1 = 10, 2 = 20, 3 = 30, 4 = 40, and 5 = 50.

TABLE 5.
Summary of similarity analysis

Number of plots	31
Mean similarity (%)	67,2
Standard deviation	6,7
Minimum similarity (%)	49,4
Maximum similarity (%)	77,5
Mean similarity for most similar pairs of plots	37,1
Standard deviation	10,7

Changes in relative abundance of species

Mean cover per species, calculated as for life forms, and frequency in both surveys are presented in Table 6 (less important species are omitted).

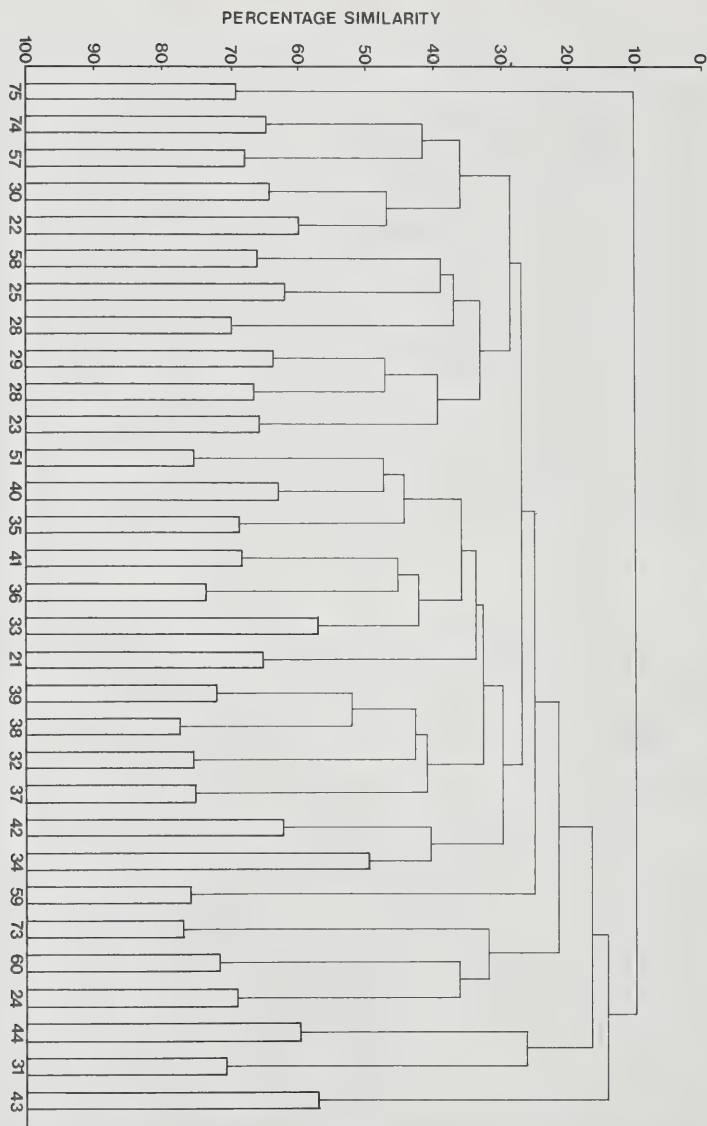


FIG. 8.

Dendrogram for the cluster analysis of permanent plot records (see text). The lowest branches (highest similarity) represent degree of similarity between successive records on each plot, and the next lowest, the degree of similarity between pooled records of most similar pairs or larger sets of plots.

TABLE 6.

Calculated cover percentage and frequency of common plant species in Kasteelkloof

Family	Species	Mean cover %		Frequency (number of plots)	
		1971	1977	1971	1977
Restionaceae	<i>Restio filiformis</i> Poir.	8,1	7,6	22	21
	<i>R. gaudichaudianus</i> Kunth	7,6	7,9	14	13
	<i>Chondropetalum paniculatum</i> Pillans	7,2	6,3	17	15
	<i>Staberoha cernua</i> (L.f.) Dur. et Schinz	6,6	6,1	18	17
	<i>Hypodiscus argenteus</i> Mast.	6,2	5,4	16	15
	<i>Restio cuspidatus</i> Thunb.	4,1	4,0	18	19
	<i>Thamnochortus dichotomus</i> (Rottb.) R. Br.	5,2	3,4	16	16
	<i>Leptocarpus distichus</i> Pillans	2,9	1,6	16	10
	<i>Hypodiscus aristatus</i> (Thunb.) Nees	2,6	2,4	10	10
	<i>Restio triticeus</i> Rottb.	2,6	3,1	11	15
	<i>Pentaschistis colorata</i> (Steud.) Stapf	8,3	8,7	19	19
	<i>P. curvifolia</i> (Schrud.) Stapf	2,3	2,3	11	12
	<i>Themeda triandra</i> Forsk.	2,6	1,9	3	3
Poaceae	<i>Cymbopogon marginatus</i> (Steud.) Stapf	1,0	0,7	6	4
	<i>Merxmuellera rufa</i> (Nees) Conert	2,6	4,2	15	20
	<i>Tetraria ustulata</i> (L.) C.B. Cl.	5,8	5,0	13	17
	<i>Tetraria cuspidata</i> (Rottb.) C.B. Cl.	5,0	5,7	23	22
	<i>Ficinia filiformis</i> (Lam.) Schrad.	3,7	2,9	22	18
Cyperaceae	<i>Tetraria involucreata</i> (Rottb.) C.B. Cl.	3,6	2,8	10	8
	<i>Erica taxifolia</i> Ait.	3,4	2,1	9	8
	<i>E. hispidula</i> L.	3,0	1,8	17	10
	<i>E. plukenetii</i> L.	2,8	1,8	15	11
	<i>E. grandiflora</i> L.f.	1,8	1,3	7	6
Ericaceae	<i>E. coccinea</i> L.	0,9	1,1	8	7
	<i>Erica nudiflora</i> L.	1,7	0,7	6	4
	<i>E. walkeria</i> Andr.	0,8	0,3	4	2
	<i>E. imbricata</i> L.	0,4	0,2	3	1
	<i>Phyllipia leana</i> Klotszch	1,0	0,7	5	3
	<i>Sympiezia articulata</i> (Thunb.) N.E. Br.	0,8	0,8	3	2
	<i>Serruria subsericea</i> Hutch.	1,9	1,7	4	5
	<i>Serruria rosea</i> Phillips	0,7	0,3	1	1
	<i>Leucadendron salignum</i> Berg.	1,5	1,8	6	5
	<i>L. spissifolium</i> (Salisb. ex Knight) Ion Williams	1,5	1,8	5	5
Proteaceae	<i>Protea nitida</i> Mill.	0,9	1,1	4	4
	<i>P. acaulos</i> (L.) Reichard	1,0	1,1	6	5
	<i>Ursinia crithmoides</i> (Berg.) Poir.	3,7	2,7	21	18
	<i>Elytropappus glandulosus</i> Less.	5,8	8,1	20	19
	<i>Stoebe plumosa</i> Thunb.	3,4	2,7	19	14
	<i>Corymbium glabrum</i> L.	5,0	6,6	23	25
	<i>Metalasia muricata</i> (L.) R. Br.	3,3	1,9	14	9
	<i>Euryops abrotanifolius</i> (L.) DC	2,5	1,6	5	7
	<i>Corymbium scabrum</i> L.	1,5	1,8	9	11
	<i>Cliffortia ruscifolia</i> L.	3,9	1,8	10	9
Others	<i>Anthospermum aethiopicum</i> L.	3,0	3,1	8	7
	<i>Montinia caryophyllacea</i> Thunb.	3,4	3,7	9	9
	<i>Anthospermum ciliare</i> L.	2,9	3,0	17	19
	<i>Heeria argentea</i> (E. Mey.) O. Kuntze	1,6	2,4	5	5
	<i>Widdringtonia nodiflora</i> L. Powrie	1,1	1,3	3	4
	<i>Maytenus oleoides</i> (Lam.) Loes.	0,5	0,5	4	3

Species turnover

Changes in the number of species are summarised in Table 7. Losses refer to species which occurred in a relevé in the first survey but not in the second survey. Additions are the opposite.

TABLE 7.
Species turnover observed in Kasteelkloof plots
(see text for explanation)

	Losses	Additions
Total over all plots	336	314
Number of species involved	171	149
Net change in species	40	47
Mean per plot	10.13	10.87
Minimum per plot	2	1
Maximum per plot	17	26
No. of sp-records with cover-abundance value		
r	103	26
+	211	267
1	18	17
2	4	4

DISCUSSION

Plant community structure

Relative importance of growth forms as summarised in Table 2 shows that there has been little overall change in plant community structure. Any differences that do occur are generally too small to be considered significant. The disappearance of seed-regenerating trees is due to the removal of pines, and does not reflect any change in the natural vegetation.

Most estimates of cover were lower in 1977 than in 1971 (22 lower, 9 higher: Table 3). Canopy cover appears not to have recovered fully in the six years after the fire. However, the major changes in cover indicated, for example, in the cases of plots 23 and 32 are probably due partly to observer error, exaggerated by the method used here to scale cover-abundance categories for our calculations. Inspection of successive photographs did not indicate such large changes in cover at any plot.

Plant species diversity measures changed little. The mean number of species per plot remained nearly the same. Of 260 species recorded in 1971 and 267 recorded in 1977, 220 were common to both surveys. Of the 40 species which disappeared after 1971, 29 occurred only once and 7 occurred only twice. Fifteen of these were not positively identified and two were pine species. Of 47 species which were added in 1977, 27 occurred only once and 8 occurred only twice. Ten of these were not positively identified, and a number may have been misidentified. Thus these changes are due in some measure to observer error.

Botanical composition

Percentage similarity, as summarised in Table 5, indicates the degree of compositional change which has taken place in each plot. Although some change has taken place in each plot (i.e. no plot is 100 % similar to what it was six years before) composition of the stand in each plot resembled that of the pre-burn stand more closely than any other stand. In fact the average percentage similarity between the pairs of successive records is much greater than the average between different but most similar pairs of plots (Fig. 8).

Changes in mean cover and frequency for some common species are summarised in Table 6. The Restionaceae, Poaceae and Cyperaceae, which are almost exclusively vegetative in mode of regeneration following fire, show little change.

On the other hand the Ericaceae, which rely for regeneration on seed reproduction, show a general reduction in both cover and frequency although they have by no means disappeared. Proteaceae, Asteraceae and some other taxa showed little change.

The species turnover recorded in Table 7 is not as marked as it seems. One hundred and three losses were represented by records of species with cover abundance values of r (i.e. represented in a given plot by a single small individual or shoot), and 211 by records with values of +. Additions were records mainly with values of + (267) though some had values of r (26).

On re-inspection of the field data and certain sites in the field, it became obvious that some additions or losses are due to misidentification, or incomplete identification of species, or to species being overlooked. It seemed that all or nearly all additions or losses in the cover-abundance category 2 can be attributed to misidentification. For instance *Tetraria flexuosa* (Thunb.) C.B.Cl. with a cover-abundance value of 2 in plot 34 disappeared but *Tetraria ustulata* was added to the list with a cover of 2; these two species may be confused when in the vegetative state. Some species "lost" from a plot were found in the surround, and some additions to the plot were previously found in the surround. Thus, some turnover is real, but much is spurious, due to sample and observer error. Apparent turnover is in any event confined mainly to rare species, while frequency and relative cover of more important species showed little change (cf. Table 6).

CONCLUSION

This study clearly illustrates the difficulties facing the field ecologist who studies plant communities in the fynbos, in that species' identification is a real problem even for those with experience. Where 60 or more species are enumerated in a sample unit the task merely of compiling the list without inadvertently omitting or misnaming a species is a major one, the more so when work schedules require fairly rapid sampling. This problem is compounded by the fact that

the taxonomic status of many species is poor, and this is especially so of important Cape families such as Cyperaceae and Restionaceae.

The method of monitoring vegetation as applied here was designed to detect only major trends and not for subtle changes over shorter periods of time. The rugged terrain renders intensive sampling impracticable, and precludes any quantitative estimate of important community parameters such as biomass and cover, for the whole catchment. Rare species (not included in Table 6) proved of little value as indicators of trend, and can be used only with the greatest caution. Useful ecological data will accumulate from repeated assessments of the sample, but their value must be increased through improved field identification of plant specimens, and more effective field procedures in general. Our experience with this sample has shown clearly that observers should work in pairs, not only to reduce fatigue by alternating roles of observer and recorder, but also to search jointly and so reduce the likelihood of overlooking or misidentifying species (Preston, 1979). It is plainly a false economy to work alone.

In spite of the relatively imprecise data from our samples we conclude that there has been little change in the plant communities in Kasteelkloof from their condition before the burn of 1971 to that before the 1977 burn, except that canopy cover apparently declined. Height, species diversity, species composition, and life-form composition returned essentially to pre-burn levels, with a few important exceptions. Post-fire succession is apparently of the "autosuccessional" type, where the initial floristic composition of the regenerating stand is very like that of the pre-burn stand and in turn determines composition of the developed stand (Hanes, 1971; Kruger, 1979). However, there appears to have been a meaningful reduction in the incidence and importance of certain shrubs which survive fire only through seed regeneration (e.g. Table 6: *Erica hispidula* and *E. plukenetii*). Field observations and comparison of photographic records indicate reduced abundance of other seed-regenerating shrubs, such as *Leicadendron microcephalum* Gandoger (see Fig. 17).

Changes in these communities (or the apparent lack of change) must be interpreted in relation to the history of the catchment. Most of the vegetation was burnt at 9–11 years' age in 1963 and 1965, and was therefore six to eight years old when the first experimental burn was applied in 1971. Furthermore, gully erosion in parts and tentative signs of grazing suggest significant deflective influences in the first half of the century. In consequence, the vegetation when sampled in 1971 is likely to have been altered from a natural condition. For example, *Protea laurifolia* Thunb., though fairly abundant as large, mature shrubs along the rocky scarp that runs through the area, occurred elsewhere mainly as scattered juvenile plants. We have seen that *P. laurifolia* is a species whose individuals tolerate a fairly intense fire but does not regenerate vegetatively if scorched off. Youth periods are rather long, and population maintenance depends on reasonable rates of survival rather than on rapid development

to maturity between fires: thus, when adults of a sub-population are depleted local extinction may become likely. It seems that past influences in Kasteelkloof had depleted *P. laurifolia*, which probably dominated many communities previously. The combined effects of *Hakea* encroachment, and the subsequent eradication operations, could have been responsible for this.

Hakea stands were extremely dense, like the notorious concentrations in the adjoining Wemmershoek catchment (i.e. more than about 100 individuals per ha—J. A. Fenn, 1978, pers. comm.), and this is born out by the abundance of old follicles and partly burnt stems which litter the ground over much of the catchment. These dense stands should have suppressed the natural vegetation to a large extent. The subsequent control treatment, which consists of felling the *Hakea* and burning the veld 12 to 24 months afterwards, would have resulted in further suppression of the vegetation (by the mass of reclining stems), and the hot fire would have had a marked impact on regeneration and subsequent community structure.

The net effect of this and other influences in the catchment would be expressed as (1) relative poverty of shrub life forms in the vegetation, (2) relatively low canopy cover and (3) relatively low strata, compared with the natural communities normally to be encountered in such areas. This is confirmed by field observation, and reflected in the photographs. The relatively short interval between fires should also tend to reduce the incidence of shrub species which rely on seed for regeneration (Jordaan, 1949).

Consequently, the effect of the experimental burning régime would be less than is likely to have been the case if the vegetation were in a pristine condition. Recovery to the pre-burn condition was relatively rapid because species that develop slowly have already been depleted. It is therefore not permissible to argue from our results that fynbos communities in general will not change if subject to regular fire at the relatively short interval of six years. Our and others' observations of vegetation subjected to short rotation fire régimes elsewhere show the opposite.

Nevertheless, the impact of the experimental régime is in some respects less than may have been predicted from present hypotheses, which suggest that fynbos plant species are vulnerable to short rotation burns (Jordaan, loc. cit.). Many seed-regenerating shrubs survived the 1971 burn (see Table 7; many others such as *Serruria rosea*, were observed in the field), and this agrees with observations (Kruger, 1979) that though there is considerable variation in the demography of such species, many mature fairly quickly. It is probable, however, that the six-year burning rotation would steadily deplete seed-regenerating shrub populations because the stock of seed in the populations is not allowed to grow to optimum levels. As the experiment progresses this postulation may be tested rigorously by comparison with response of vegetation to 12-year burns in Zachariashoek sub-catchment.

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